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NEW BEDFORD HARBOR ENDANGERMENT ASSESSMENT

TASK 2.6

ECOTOXICITY ASSESSMENT

DRAFT LETTER REPORT

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Waste Programs Enforcement
Washington, D.C. 20460

Work Assignment No.	:	560
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PRC No.	:	15-5600-78
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December 12, 1986

Mr. Frank Ciavettieri
U.S. EPA Region 1
JFK Federal Building
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Dear Mr. Ciavettieri:

PRC Environmental Management, Inc. and its subcontractor, Alliance Technologies Corporation (formerly GCA Corporation, Technology Divisions) are pleased to submit two reports entitled, "New Bedford Harbor Endangerment Assessment, Task 2.5 - Exposed Species Analysis - Draft Letter Report" and "New Bedford Harbor Endangerment, Task 2.6 - Ecotoxicity Assessment - Draft Letter Report", for work assignment no. 560. Please accept my apology for the delayed submittal of these deliverables.

Should you have any questions or wish to discuss these reports or the work assignment in general with me directly, please feel free to do so.

Thank you for your assistance and cooperation.

Sincerely,
PRC Environmental Management, Inc.

Eric S. Morton

Eric S. Morton
Public Health Scientist

cc: Nancy Deck
Bruce Bakaysa (letter only)
Barb Myatt, Alliance Technologies Coprporation

DOCUMENT FORMAT

Although this document is being submitted as a Letter Report, it constitutes part of an Endangerment Assessment and as such, follows a format whereby it can be incorporated into the Endangerment Assessment.

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Ecotoxicity Assessment

The ecotoxicity assessment consist of two subtasks. The first is a Toxicological Evaluation which includes a review of the current scientific literature, placing emphasis on site-specific studies and focusing on species of importance in New Bedford Harbor. A toxicity profile for PCBs is developed which presents information on modes of exposure, acute and chronic effects, and the concentrations of PCBs shown to elicit those effects. The extent to which this information can be used to characterize the risk to the aquatic ecosystem is evaluated, based on the applicability of the studies to New Bedford Harbor. The second subtask is the Concentration Response Assessment which involves a discussion of the ambient water quality criteria for PCBs, and also assesses the results of the most recent site-specific ecotoxity experiments, many of which are as yet unpublished.

Toxicological Evaluation--

PCBs are highly lipophilic and bioconcentrate readily in tissues exposed to water concentrations that are often below the usual detection limits. Thus, when an evaluation of the impact of PCBs on the aquatic environment is performed, it is necessary to relate data gathered under laboratory conditions (relatively pure mixtures) to effects in the natural environment. In addition, there is evidence that percentages of chlorine change with time and location as the mixtures are naturally degraded and transported through the environment. Direct water exposures appear to represent a greater hazard to fish than dietary exposure, although both contribute to tissue residues (Stalling and Mayer, 1972). However, in the environment the kinetics of residue uptake from dietary sources could prove more important, since PCBs have a high affinity for sediments and PCBs can readily enter the food chain (Stalling and Mayer, 1972).

The following ecotoxicity data (site-specific and nonsite-specific) are provided for selected species known to inhabit New Bedford Harbor (past or present) and provide specific data as to the effect of exposure to PCBs for these organisms. Also, these individual profiles attempt to predict the health of populations of marine organisms at New Bedford Harbor based on these toxicity concentration response levels.

Winter flounder (Pseudopleuronectes americanus)--Exposure to pollutants, like PCBs, can effect individual fish directly, but often result in deleterious impacts on successive generations through bioaccumulation in ovarian eggs. Since organic pollutants have a high affinity for lipids, they are particularly prone to bioaccumulation in the eggs. Contaminated eggs may exhibit reduced fertilization, embryo and larval mortality, reduced growth, and abnormal development, all of which decrease the chances for survival of the population (Rosenthal and Alderice, 1976; Sprague, 1971).

Black, et al. 1986, examined the exposure of adult winter flounder Pseudopleuronectes americanus to polluted natural environments prior to spawning, and the possible impact of this exposure upon their progeny. This study used fish exposed to contaminated water in New Bedford Harbor. Fish were induced to spawn and eggs were fertilized. Eggs were reared in uncontaminated water and biological responses recorded. Percent embryo survival, percent larval survival, percent metamorphosis, and size at hatch were all measured. The results of the study showed that winter flounder eggs from New Bedford Harbor contained significantly higher levels of PCBs (36.9 μg/g dry weight) than those from Fox Island fish (1.08 μg/g dry wt.). However, more importantly, the larvae hatched from these eggs were significantly smaller in length and weight. Those from New Bedford Harbor averaged 2.96 mm in length and 0.018 mg in weight, while larvae from Fox Island averaged 3.22 mm in length and 0.022 mg in weight. This represents a 6 percent difference in length and an 18 percent difference in weight. For larval fish, the consequence of smaller size at hatch may be severe, since the best chances for survival require rapid growth (Ware, 1975; Marr, 1956; Cushing, 1974). Small larvae are ineffective predators and are more susceptible to predation, due to reduced visual and swimming ability. The high metabolic cost of inefficient prey capture reduces the energy available for growth and the rudimentary digestive tract results in inefficient digestion as well (Lawrence, 1977; Baxter, 1963).

Other studies conducted in this area and research tend to support the connection between PCB exposure and reduced embryo and fry survival. Hansen, et al. (1973), observed these effects in the eggs of the sheepshead minnow (Cyprinodon variegatus) exposed to Aroclor 1254 at concentrations greater than 7 μg/g.

The site-specific study conducted by Black, et al, with winter flounder shows chronic toxicity in individuals taken from zone 4. PCB concentrations are known to be significantly higher in zones 1, 2, and 3, suggesting that the toxic effects manifest there are likely to be more pronounced. The data presented have significant implications for the winter flounder populations in New Bedford Harbor and should be considered when evaluating the risk to the aquatic ecosystem of the harbor.

Amphipod (Ampelisca abdita)/sheepshead minnow (Cyprinodon variegatus)--A preliminary data report has been produced (Hansen, 1986), which shows toxicity in the amphipod, *Ampelisca abdita*, and the sheepshead minnow, *Cyprinodon variegatus*, exposed to the PCB contaminated sediments of New Bedford Harbor. This study involved collecting sediment samples, chemically analyzing the sediments for PCBs and metals, and determining the effect of the sediments on the survival of amphipods and the survival and reproduction of fish.

Sediment samples were taken at 14 points distributed through zones 1 to 4. Analysis confirmed previous data, indicating that PCB concentrations in sediments become progressively higher in zones 4 through 1. Figure 1 shows the sediment sampling locations within New Bedford Harbor and Table 1 shows the concentrations of Aroclor 1254 and selected metals in the sediments from zones 1, 2, and 3. Concentrations ranged from 540 μg/g in zone 1 to 3.8 μg/g in zone 3. *Ampelisca abdita* (amphipod) were exposed to the range of contaminated sediments and both 4-day and 10-day percent mortalities measured. In addition, the daily average percentage of amphipod emergence was recorded. These results are listed in Table 2. Exposure to the most contaminated sediments from sampling location 14 in zone 1 caused 100 percent mortaliity after 10 days. Sediment dilutions elicited a biological response consistent with the PCB concentrations of the sediments, and the most contaminated sediments showed a no effect concentration of 6 percent.

Hansen also studied the toxicity of the sediments to the sheepshead minnow. The results are presented in Table 3. Adult fish exposed to the most contaminated sediments showed 100 percent mortality after 29 days. The occurrence of fin rot was prevalent in surviving fish and their progeny. The study also showed reduced survival of embryo and fry from adults exposed to sediments from zones 1 and 2.

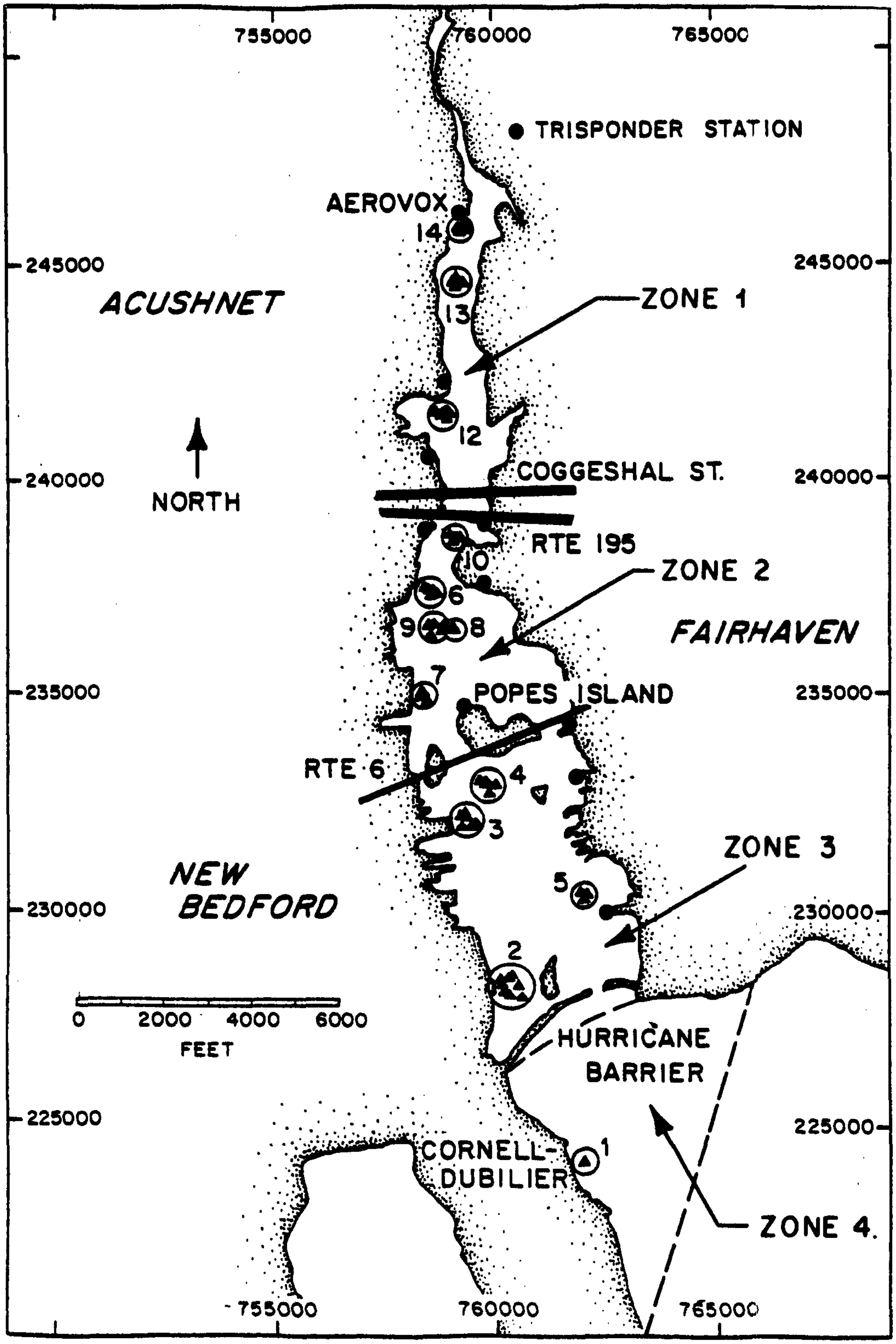

Figure 1. Sediment sample locations.

TABLE 1. CONCENTRATIONS ($\mu g/g$ DRY WEIGHT) OF POLYCHLORINATED BIPHENYLS (AROCLOR 1254) AND SELECTED METALS IN SEDIMENTS FROM NEW BEDFORD HARBOR

	Location		
Substance	Popes Island to hurricane barrier (Sta. 2-5)	Popes Island to I-195 (Sta. 6-10)	North of I-95 (Sta. 12-14)
PCB	3.8 - 5.4	13.6 - 19.3	151 - 540
Cd	3.8 - 4.4	5.82 - 10.3	46.8 - 78.4
Cu	368 - 648	892 - 1800	1,180 - 2,500
Cn	177 - 343	421 - 944	710 - 1,700
Fe	11,600 - 15,700	14,300 - 22,600	16,900 - 19,400
Mn	98.8 - 141	103 - 165	139 - 156
Ni	18.5 - 27.3	32.6 - 50.5	142 - 214
Pb	124 - 174	235 - 524	617 - 882
Zn	264 - 392	485 - 655	2,150 - 2,530

Source: Hansen, D. J. (1986). Preliminary Data Report, NBH Project.

TABLE 2. AMPELISCA ABDITA SOLID PHASE TEST SEDIMENT GRADIENT EXPOSURES

Sediment	% Mortality 4 day	% Mortality 10 day	Daily average % of amphipods emerged
Reference	2.7	13.3	0.0
NBH 5	2.2	11.1	6.6
NBH 7	25.6	46.7	13.4
NBH 6	39.3	65.6	19.9
NBH 8	34.0	73.3	24.1
NBH 12	67.6	92.2	34.1
NBH 14	96.7	100.0	NM*

*Not Measured

Source: Hansen, D. J. (1986). Preliminary Data Report, NBH Project.

TABLE 3. EFFECTS OF NEW BEDFORD HARBOR (NBH) SEDIMENTS ON SHEEPSHEAD MINNOWS. ADULT FISH, (12 FEMALES AND 6 MALES PER TREATMENT) WERE EXPOSED TO A REFERENCE SEDIMENT FROM CENTRAL LONG ISLAND SOUND AND TO SEDIMENTS FROM FIVE LOCATIONS WITHIN NBH. FEMALES WERE INJECTED WITH HUMAN CHRONIC GONADOTROPIN AND STRIPPED OF THEIR EGGS. THE EGGS FROM 4-5 INDIVIDUAL FEMALES WERE FERTILIZED WITH MILT FROM MALES TAKEN FROM THE SAME TREATMENT AS THE FEMALES. THE EFFECTS OF EXPOSURE OF PARENTAL FISH ON DEVELOPMENT AND SURVIVAL OF EMBRYOS AND RESULTANT HATCHED FISH WAS ASSESSED BY HOLDING PROGENY IN CLEAN FLOWING SEAWATER FOR 28 DAYS

	Parental fish exposure (29 days)		Progeny (28 days)			
			Embryos		Fish	
Treatment	Survival	Survivors with fin rot or mouth erosion	Survival to Day 1	Survival: day 1 to hatch	Hatched fish survival	Incidence of fin rot
REF-1	100%	0%	69%	94%	99%	0%
REF-2	100%	0%	54%	66%	88%	2%
NBH-5	100%	0%	42%	65%	65%	0%
NBH-7	94%	0%	11%*	45%	55%	4%
NBH-8	100%	0%	30%	73%	88%	2%
NBH-12	72%*	42%*	15%	56%	20%*	45%
NBH-14	0%*	80%*,**	17%	55%	58%	23%

* Significantly different from Ref-2.
**Restarted with 10-day exposure.
Source: Hansen, D.J. (1986). Preliminary Data Report, NBH Project.

It is clear from the study that New Bedford Harbor sediments from the upper harbor region are acutely toxic to both amphipods and the sheepshead minnow. This study will be of particular importance for characterizing the risk to the aquatic ecosystem of New Bedford Harbor.

Eastern oyster (Crassosstrea virginica)--As stated in the Exposed Species Analysis, the Eastern oyster can be found in low abundance in zones 2 through 4 in New Bedford Harbor. Although no site-specific ecotoxicity evaluations have been conducted with this species, it has been used extensively in PCB toxicity testing. A study which exposed young oysters (31 mm mean height) to Aroclor 1254 via flowing unfiltered seawater, showed significant toxic effects. Oysters exposed to 5 μg/L (ppb) of Aroclor 1254 over a 24-week period showed a significant reduction in growth rate, as measured by height and unwater weight. The greatest PCB residue found for this group was 425 mg/kg (ppm), reflecting a bioconcentration factor of 85,000 (Lowe, 1972). The results of this study are supported by a similar flow through experiment which used Aroclor 1016. Decreased growth was apparent, and an EC_{50} of 10.2 μg/L (ppb) was reported (Hansen, 1974a). It has been shown that depuration in PCB-free water occurs readily and that tissue recovery is good. The oysters exposed to 5 μg/L retained less than 0.3 ppm after 28 weeks (Lowe, 1972).

These studies, although not site-specific, are of some use in characterizing risk to the Eastern oyster and phylogenetically similar species in New Bedford Harbor.

Grass shrimp (Palamonetes pugio)--Toxicity testing of the grass shrimp with PCBs has focused on the species *P. pugio*. Although the more common species found in New Bedford Harbor (zones 3 and 4) is *P. vulgaris*, the phylogenetic similarity of these two species allows extrapolation to be made on the toxic effects of one species to another with some degree of confidence. Both acute and chronic effects have been observed at concentrations below 50 μg/L. A 96-hour acute toxicity test, which exposed grass shrimp to Aroclor 1016, showed an LC_{50} of 12.5 μg/L (Hansen, 1974a). A study conducted with Aroclor 1254 and an exposure duration of 16 days showed mortality at 4 μg/L (Nimmo, 1974). Water efflux was apparent, which affected the metabolic rate in shrimp exposed to 25-45 μg/L for 4 days in a study with Aroclor 1254 (Roesljadi, 1976), and avoidance of Aroclor 1254 was observed in shrimp exposed to 10 μg/L after 1 hour (Hansen, 1974b).

The grass shrimp has shown bioaccumulation factors of between 3,000 and 11,000 for 16-day exposures at 4.0 μg/L (Nimmo, 1974). The sensitivity of this organism to PCBs, its tendency to bioaccumulate these compounds, and its importance in the food chain will be considered when addressing the overall risk to the ecosystem in New Bedford Harbor.

Estuarine Communities--Very little data exist on the effect of PCBs on estuarine animal communities, however, a study on the effects of Aroclor 1254 on composition of developing estuarine animal communities in the laboratory (Hansen, 1974c), is useful in trying to discern expected effects to developing aquatic communities in New Bedford Harbor.

The effect of Aroclor 1254 on development of estuarine communities was investigated by comparing number, species, and diversity of animals that grew from plankton larvae in apparatuses continuously contaminated with 0.1, 1, or 10 μg/L of PCB for 4 months, with animals from an identical apparatus that was not contaminated. Aroclor 1254, dissolved in polyethylene glycol 200, was metered by a syringe pump into the water as it entered the secondary constant head box of each experimental apparatus. The same amount of polyethylene glycol (2 mL/day, 0.6 mg/L) was metered into the control apparatus (Hansen, 1974c.)

Concentrations of Aroclor in test water and sediment were determined by gas chromatography. Water from the secondary head box of each apparatus was analyzed twice a month (Table 4). Concentrations throughout this box were uniform; water from each standpipe, analyzed once during the 10 μg/L exposure, averaged 7.9 μg/L (range 6.8-8.7 μg/L). Sediment cores from 4 to 10 aquaria from each apparatus were analyzed at the end of the exposure (Table 4). At the end of the 4-month exposure, animals were scraped from the sides of the aquaria and the contents of the aquaria siphoned into a 1 mm mesh sieve (Hansen, 1974c).

TABLE 4. RANGE AND CONCENTRATION OF AROCLOR 1254 IN WATER AND SEDIMENT FROM EXPERIMENT AND CONTROL APPARATI. WATER WAS ANALYZED TWICE MONTHLY AT THE END OF THE 4-MONTH EXPERIMENT. LIMIT OF QUANTIFICATION WAS 0.1 μG/L IN WATER AND 0.015 MG/KG (DRY WEIGHT) IN SEDIMENTS. CORRECTION FOR RECOVERY (>70%) IS NOT INCLUDED

	Concentration in water (μg/L)		Concentration in water (μg/L)	
	Measured		Measured	
Nominal	Average	Range	Average	Range
Control	None		None	
0.1	0.1	0.1-0.1	0.1	0.05-0.18
1.0	0.6	0.48-0.72	0.36	0.25-0.42
10.0	6.7	5.2-7.8	2.0	1.5-2.5

Source: Hansen, 1974c.

A large number and variety of animals were found in all aquaria (Table 5). Of the 67 species from 9 phyla, 27 were mollusks (15 pelecypods and 12 gastropods), 23 annelids, 6 arthropods, 3 chordates, 2 coelenterates, 2 enchinoderms, 2 nemerteans, 1 brachiopod, and 1 bryozoan. Anthropods were the most abundant (3,842) of the 5,897 animals followed by chordates (1,302), annelids (448), mollusks (219), and animals from other phyla (86). The two most abundant species were the amphipod, Corophium volutator (3,770), and the turnicate, Molgula manhattensis (1,164) (Hansen, 1974). Both these species are known to inhabit New Bedford Harbor.

The number of species in each aquarium was altered by Aroclor 1254 (Table 5). The total number of species and the number of species from each phylum in the control, 0.1, and 1 μg/L contaminated aquaria were similar. However, there were significantly fewer species and the species composition differed in the aquaria contaminated by 10 μg/L of the PCB. The greatest shifts in species composition were found in arthropods, bryozoans, and mollusks. ALthough there were significant reductions in the number of molluscan species in the 10 μg/L aquaria, there was no difference in the gastropod-pelecypod ratio (Hansen, 1974c).

Thirteen of the species tested are known to inhabit New Bedford Harbor, and although inferences to actual effect of exposure to Aroclor 1254 are not verifiable using laboratory data, this experiment can still serve as a predictive tool for determining how community structures at New Bedford Harbor can be affected. It is not possible from this data to determine how the absence of individual species may effect the community as a whole, but clearly these data show that exposure to Aroclor 1254 in the range of 6.8 to 8.7 μg/L in water (measured concentrations) is acutely toxic to estuarine organisms and possibly chronicly toxic at even lower concentrations.

Phytoplankton--Harvestable marine fish resources are believed to result from an abundance of large phytoplankton at the base of relatively short food chains (O'Connors, 1978). Small phytoplankton, by contrast, are thought to produce longer food chains, leading to ecosystems containing numerous ctenophores, jellyfish, and other gelatinous predators (O'Connors, 1978).

TABLE 5. SPECIES AND TOTAL NUMBER OF ANIMALS COLLECTED FROM THE EFFLUENTS OF 10 CONTROL AQUARIA AND 10 AQUARIA CONTAMINATED FOR FOUR MONTHS WITH 0.1, 1 OR 10 μg/L AROCLOR 1254.

Taxon	Control	0.1 μg/L	1 μg/L	10 μg/L
Annelida				
Eupomatus dianthus	1	1	0	0
E. protulicola	0	1	1	0
Neanthes succinea	1	2	2	0
Total	2	4	3	0
Arthropoda				
Balanus sp.[a]	10	2	2	1
Caprella sp.	0	8	4	0
Clibanaris tricolor	0	1	0	0
Corophium volutator[a]	7	15	32	1
Eurypanopeus depresus	5	2	5	0
Neopanope texana[a]	10	6	3	0
Pagurus longicarpus[a]	1	0	0	0
Pinnixa chaetopterana[a]	1	0	0	0
Upogebia affinis[a]	1	1	0	0
Decapod zoea, unident sp.	0	0	1	0
Portunidae, unident sp.	2	1	0	0
Pycnogonidae, unident sp.	0	0	3	0
Total	37	36	50	2
Chordata				
Bostrichobranchus pilularis	3	0	0	0
Branchiostoma caribaeum	1	0	1	0
Molgula manhattensis[a]	72	103	304	35
Total	76	103	305	35
Coelenterata				
Leptomedusae*, unident sp.	1	1	1	1
Echinodermata				
Hemipholis elongata	1	0	3	0
Ectoprocta				
Membranipora tenuis*	1	1	1	0
Mollusca				
Anadara ovalis[a]	1	0	0	0
A. transversa[a]	12	0	4	1
Bittium alternata	0	1	0	0
B. varium	3	0	1	0
Crassostrea virginica[a]	2	0	1	1
Doridella obscura	12	1	2	1
Laevicardium mortoni[a]	1	0	0	0
Mitrella lunata[a]	2	0	2	2
Musculus lateralis	1	0	1	0
Nassarius albus[a]	2	0	0	0
Tagelus divisus	1	2	0	0
Eolidacea, unident sp.	1	1	1	3
Total	38	5	12	8
Totals: Animals	156	150	375	47
Species	27	18	21	9

*Colonies: Counted as one animal.
[a]Species - Known to inhabit New Bedford Harbor, GCA 1986a.
Source: Hansen, D. J. Aroclor 1254: Effect on composition of developing estuarine animal communities in the laboratory. Marine Science, Vol. 18, 1974.

The relative abundance of large or small phytoplankton has been related to natural variations in nutrient availability, light, mixing, zooplankton grazing, and to man-made pollutants, which stimulate the growth of small phytoplankton (O'Connors, 1978).

There is evidence that exposure to polychlorinated biphenyls (PCBs) reduces phytoplankton biomass and causes shifts to smaller sized taxa within natural estuarine phytoplankton communities, whilst in mixed cultures differential sensitivities to PCBs may lead to changes in species composition (O'Connors, 1978).

The use of dialysis membrane chambers permits an evaluation of the impact of pollutants on natural phytoplankton assemblages under conditions approximating those found in natural waters (O'Connors, 1978). The effects of PCB (Aroclor 1254) exposure were measured on the ^{14}C uptake, chlorophyll A concentration, particle concentration, and size distribution. In addition, species composition of natural phytoplankton assemblages was measured over a 4 to 10 day period (O'Connors, 1978).

Suppression of algal growth by PCBs was dose dependent. Particle concentrations in cultures exposed to a single treatment of PCBs at 1 μg/liter were lower than those in controls for at least 3 days, although growth rates (rates of particle formation) recovered more rapidly. In cultures exposed to single treatment with 10 μg/liter or repeated treatment with 5 μg/liter, growth rates took longer to recover, and particle concentration remained lower than those in controls (PCB free) throughout the experiments (O'Connors, 1978).

Repeated treatment with 10 μg/liter ultimately destroyed algal cultures. A decline in ^{14}C photosynthetic uptake was evident after 3 to 6 days, and visual inspection showed that moribund cells, algal detritus, and bacteria dominated the cultures. Moreover, in both June and September, cultures treated with 10 μg/L exhibited clumped cytoplasms, misshapen nuclei and chloroplasts, and other morphological abnormalities (O'Connors, 1978).

Many zooplankters are selective grazers, often choosing food on the basis of size, shape, and species (O'Connors, 1978). If algal cells are too small, they may not be grazed efficiently by common estuarine and coastal copepods (O'Connors, 1978). This would alter the flow of energy through higher trophic levels reducing harvestable fish biomass.

A two-pathway hypothesis has been proposed for the transfer of biomass through marine food webs (O'Connors, 1978). One pathway leads from large phytoplankton by way of a one- to three-step food chain to fish that can be harvested by humans (O'Connors, 1978). The other leads from smaller phytoplankton through about five trophic levels to various gelatinous predations (O'Connors, 1978).

If this hypothesis is valid, then PCB pollution of coastal waters and estuaries like New Bedford Harbor could result not only in PCB contaminated fish products and diminished primary and secondary production, but also in ecosystems reduced in harvestable fish through a reduction in phytoplankton size and associated alteration of the natural food web (O'Connors, 1978).

Summary of Ecotoxicity Assessments--

These individual studies have served to describe the effects of PCB exposure to individual aquatic species and estuarine communities. Although several of these studies are not site-specific to New Bedford Harbor, they still provide insight into PCB toxicity to marine organisms at New Bedford Harbor. More importantly, the site-specific data described in this section offer concrete evidence as to the effect of some Aroclors to organisms known to inhabit New Bedford Harbor, and offer some insight into presence or absence of species associated with New Bedford Harbor. Table 6 summarizes the toxicity of PCBs to various marine organisms. This table includes the most recent studies, site-specific to New Bedford Harbor and is supplemented by the most appropriate laboratory studies, based on the organisms common to New Bedford Harbor.

Due to the complexities inherent in predator-prey or competitive relationships, the ability to predict the eventual status of the harbor is extremely complex. Although the ability to make exact, quantified determinations is limited, the ability to make qualitative, system-wide determinations is not. In New Bedford Harbor environmental exposures to PCBs is as high or higher than any other documented site. New Bedford Harbor is an estuary, the natural spawning grounds for many important marine organisms. Given the tendency for PCBs to impair reproduction, at least by toxicity to some early life stages, the environmental effects in New Bedford Harbor due to PCB exposure cannot help but be detrimental and far reaching.

TABLE 6. ECOTOXICITY PROFILE FOR PCBs IN ESTUARINE ORGANISMS

Genus and species	Common name	Zone(s)	Aroclor	Age/ size	Mode of exposure	Duration of exposure	Effect concentration (μg/L)	Effect	(BCF)	Reference
Pseudopleuronectes americanus	Winter flounder	1-8	---	Adult	Natural Env. NBH	3-4 months	---	Accumulation of PCBs in eggs. Reduced larval size at hatching.	---	Black, et al. (1986)
Cyprinodon variegatus	Sheepshead minnow	---	1254	Adult	NBH Sediments	29 days	540	100% mortality.	---	Hansen, (1986)
Cyprinodon variegatus	Sheepshead minnow	---	1254	Adult	NBH Sediments	28 days	151	80% mortaility in progeny of exposed adults. 45% showed fin rot.	---	Hansen, (1986)
Amepelisca abdita	Amphipod	5-8	1254	Adult	NBH Sediments	4 days	540	97% mortality.	---	Hansen, (1986)
Amepelisca abdita	Amphipod	5-8	1254	Adult	NBH Sediments	10 days	151	92% mortality.	---	Hansen, (1986)
Amepelisca abdita	Amphipod	5-8	1254	Adult	NBH Sediments	10 days	151	34% daily average emergence from sediments.	---	Hansen, (1986)
Crassostrea virginica	Eastern oyster	2-4	1254	---	Water	24 weeks	5.0	Reduced growth.	85,000	Lowe, (1972)
Crassostrea virginica	Eastern oyster	2-4	1016	---	Water	----	10.2	EC_{50}, reduced growth.	---	Hansen, (1974a)
Palaemonetes pugio	Grass shrimp	3 and 4	1016	---	Water	96 hours	12.5	LC_{50}.	---	Hansen, (1974a)
Palaemonetes pugio	Grass shrimp	3 and 4	1254	Adult	Water	16 days	4.0	Mortality.	32,000-11,000	Nimmo, (1974)
Palaemonetes pugio	Grass shrimp	3 and 4	1254	---	Water	1 hour	10.0	Avoidance.	---	Hansen, (1974b)
Morone saxatalis	Striped bass	2-8	1254	---	Water	48 hours	500-1,000	LC_{50}.	---	Califano, (1980)
Fundulus heteroclitus	Killifish	2-4	1221	---	Water	----	25	85% mortality.	---	Duke, (1974)
Uca pugilator	Fiddler crab	U	1254	---	Sediment	38 days	8.0	Inhibited molting.	---	Fingerman, (1977)
PHYTOPLANKTON										
Skeletonema costatum	Diatom	U	1254	---	Water	4-10 days	1-10	Reduced size of individuals and biomass.	---	O'Connor, (1978)
Skeletonema costatum	Diatom	U	1254	---	Water	3-4 days	1	Reduced chlorophyll A	---	O'Connor, (1978)
Rhizosolenia fragillisima	Diatom	U	1254	---	Water	3-5 days	10	Clumped cytoplasm, misshapened organelles.	---	O'Connor, (1978)

Concentration/Response Assessment--

The current criteria for the protection of saltwater aquatic life were developed according to U.S. EPA guidelines (U.S. EPA, 1980).

Acute Toxicity: 10 μg/liter (ppb)

Chronic Toxicity: 0.030 μg/liter (ppb)

The chronic value was actually derived as a Final Residue Value using the former FDA action level of 5.0 mg/kg (U.S. EPA, 1980), and recalculation of the criteria based on the new value (2.0 mg/kg) gives a chronic toxicity value of (0.012 μg/liter (ppb). In addition, the bioconcentration factors (BCF) used to calculate this were entirely laboratory derived (U.S. EPA, 1980), and field results determine BCFs (at least for fish) to be 10 times greater than laboratory results (U.S. EPA, 1980). Thus, the standard is "probably too high" (U.S. EPA, 1980). Average concentrations of dissolved PCBs for zones 1-5 (Battelle, 1986) are above even the current chronic value (0.030 μg/liter). Figure 2 summarizes the results of PCB ecotoxicity tests for saltwater species, which includes the chronic and acute water quality criteria, and shows the range and averages of dissolved PCB concentrations for zones 1-3. Mean values are probably underestimates because values below the detection limits (generally 0.1 ppb) were recorded as zero. Although PCBs have been shown to be acutely toxic to aquatic organisms, the specific concentration response relationships are not known. The reported concentrations for acute toxicity exceed the solubilities for some portion of PCB isomers, so actual exposure concentrations are unknown.

The above criteria are useful in discerning potential harm to marine organisms at New Bedford Harbor, because the exposure level for chronic toxicity criteria, already considered by experts as too low to be protective, is exceeded in zones 1-5 of New Bedford Harbor. The criteria set forth by U.S. EPA serves to protect all saltwater aquatic life and is not meant to be a species-specific standard. In this capacity, these criteria serve as a useful baseline characterization of potential harm to saltwater aquatic environments. Clearly the site-specific ecotoxicity data described in the Toxicological

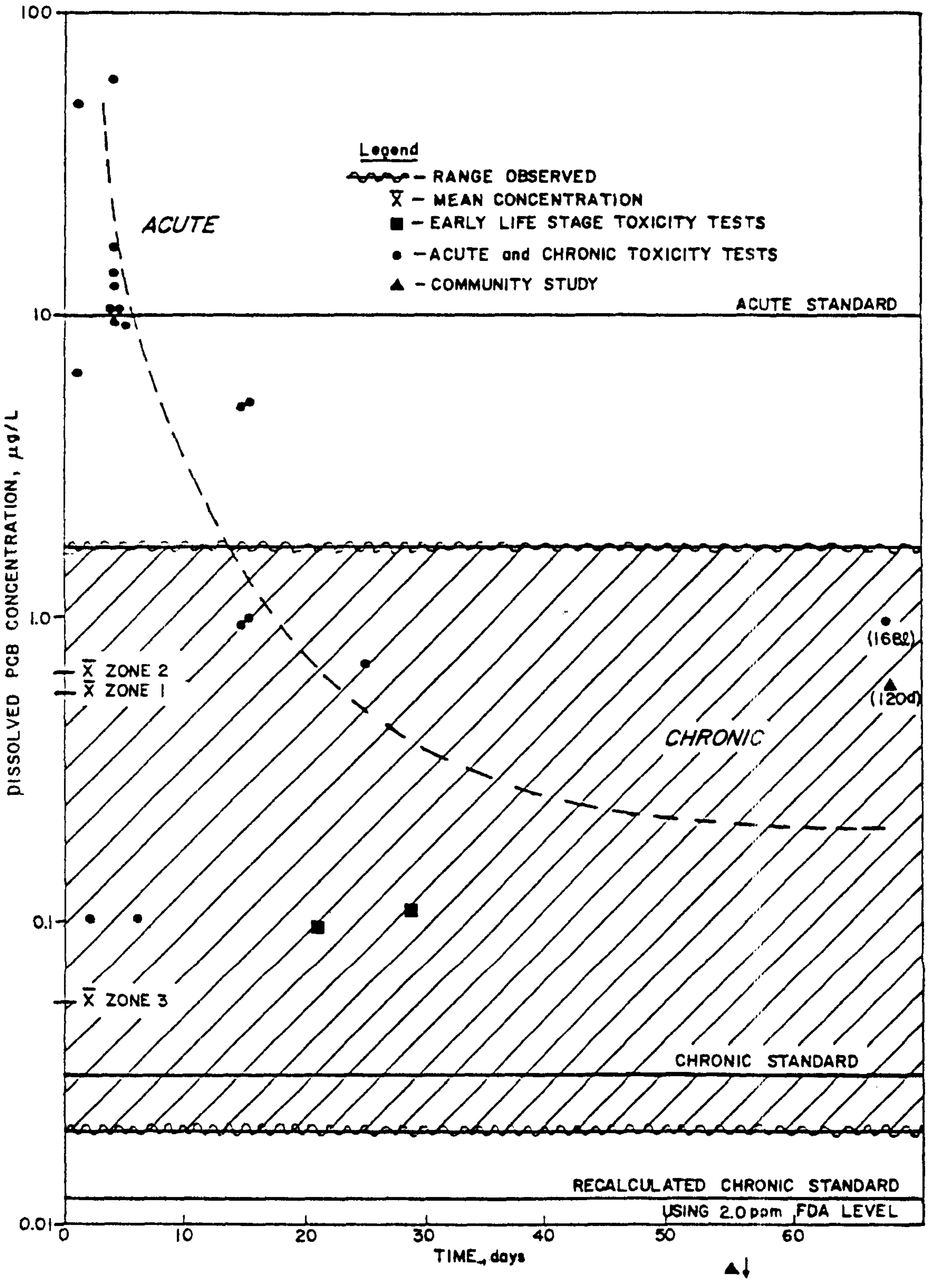

Figure 2. Summary of PCB responses of salt water species and PCB concentrations in water of New Bedford Harbor (zones 1-3). (Gentile and Schimmel, 1985).

Evaluation section are more definitive for any inferences to the deleterious effects of PCBs to marine organisms at New Bedford Harbor. The risk characterization section will be based on both site-specific and laboratory studies where applicable, in order to provide the most comprehensive assessment of risk to the aquatic ecosystem of New Bedford Harbor.

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